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(52) UK CL (Edition V)
F4S S4E2D S4F1
F4H HG17

(56) Documents Cited

GB 2347997 A	JP 2001116472 A
US 6073688 A	US 6016865 A
US 5369883 A	US 3757856 A

(58) Field of Search
UK CL (Edition T) **F4H** HG17, **F4S** S2A3 S2B11 S2B2 S2B9 S2M4 S4E2A S4E2B S4FX S4F1 S4JX S5F
INT CL[7] **F25B** 39/04, **F28B** 1/06, **F28D** 1/053 7/16, **F28F** 1/02 1/06 1/08 1/22 1/26 1/32 1/42 3/02 3/04 13/06 13/08
Other: **ONLINE: EPODOC, WPI & JAPIO**

(54) Abstract Title
Automotive heat exchanger

(57) A heat exchanger, radiator or air conditioning condenser comprises tubes 2, constructed from plates 4, joined to plate 5, each plate having dimples 9 that project toward the inside of the tube 2 and are joined to the other plate; and ridges 10 that project externally of the tube 2 and are joined to an adjacent plate. The tubes further have open ends of height H, higher than the height h of tube body 2, and adjacent tubes contact each other via faces 4a and 5a at the ends. Where the plates 4 and 5 are joined at their edges plates 4 and 5 their walls 4b and 5b overlap. The plates 4 and 5 may be made of aluminium, which comprise a high strength aluminium alloy with an aluminium brazing cladding and may be bonded together by a diffusion bonding process. Fluid flows through the tube as arrow A (fig 1) and air flows transversely across the tube as arrow B (fig 1).

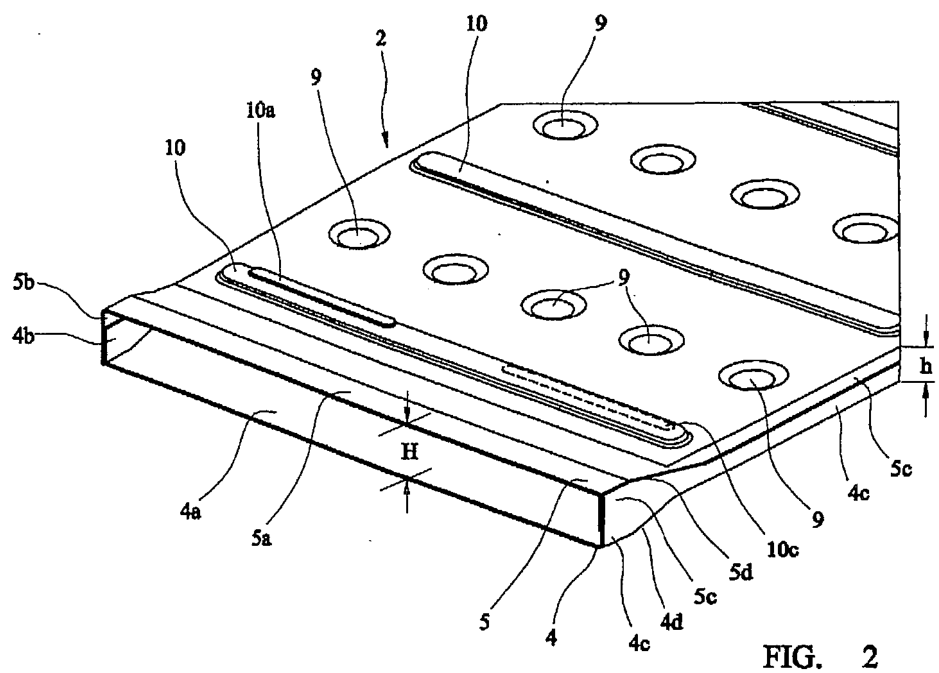

FIG. 2

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

The print reflects an assignment of the application under the provisions of Section 30 of the Patents Act 1977.

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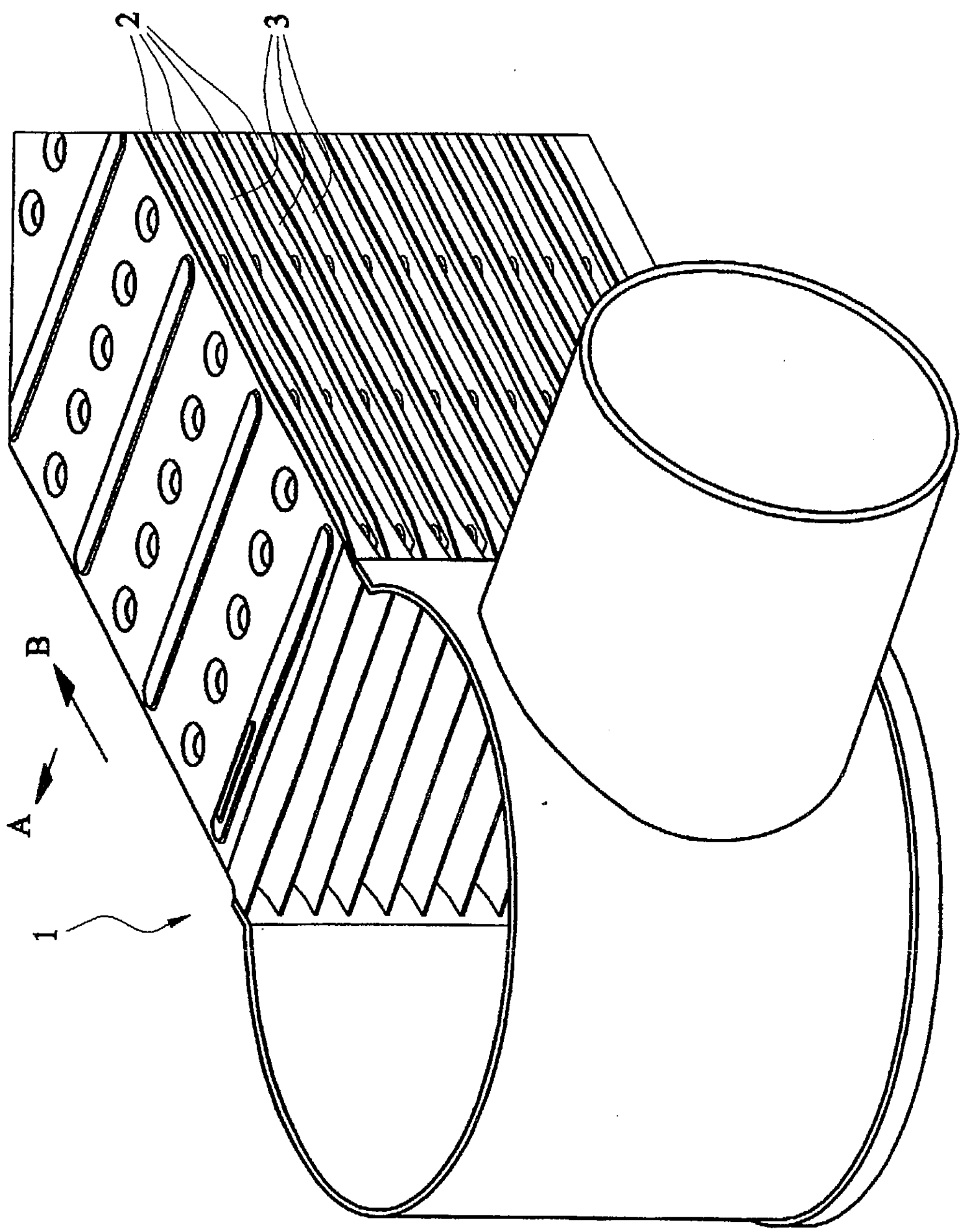

FIG. 1

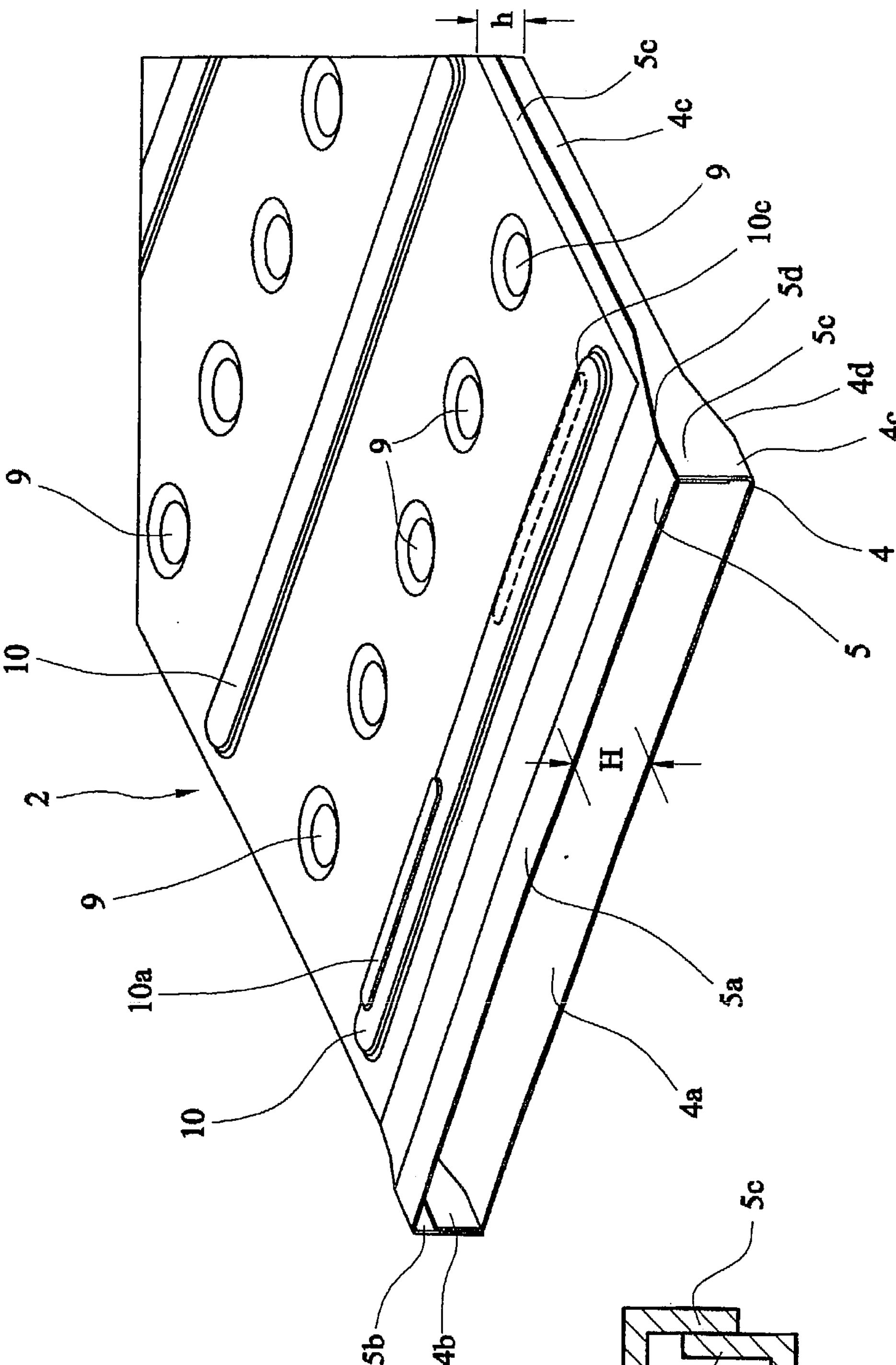

FIG. 2

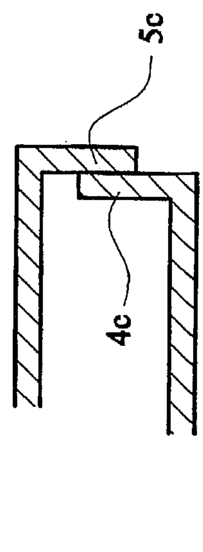

FIG. 3

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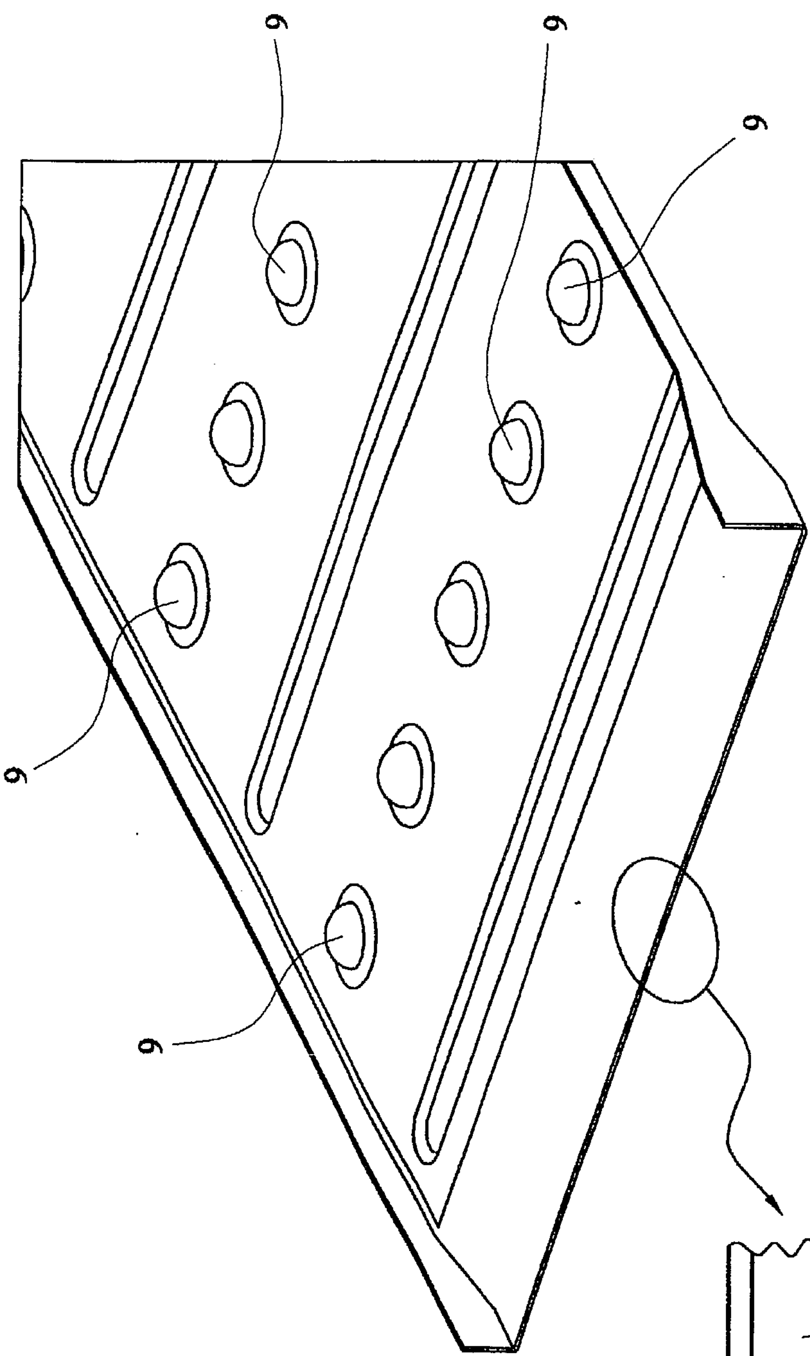

FIG. 4

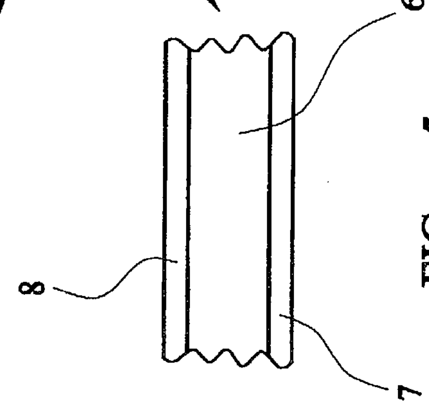

FIG. 5

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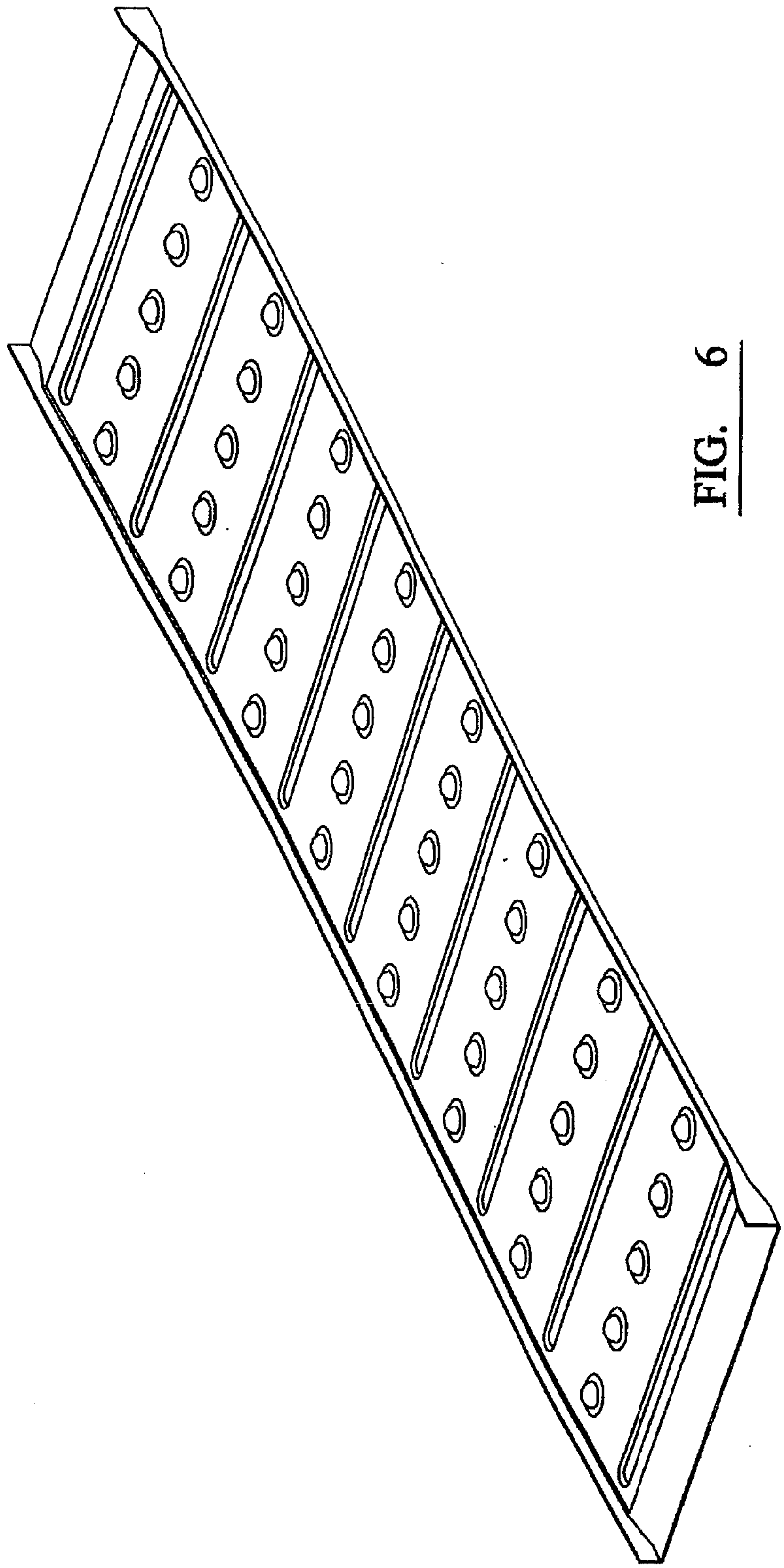

FIG. 6

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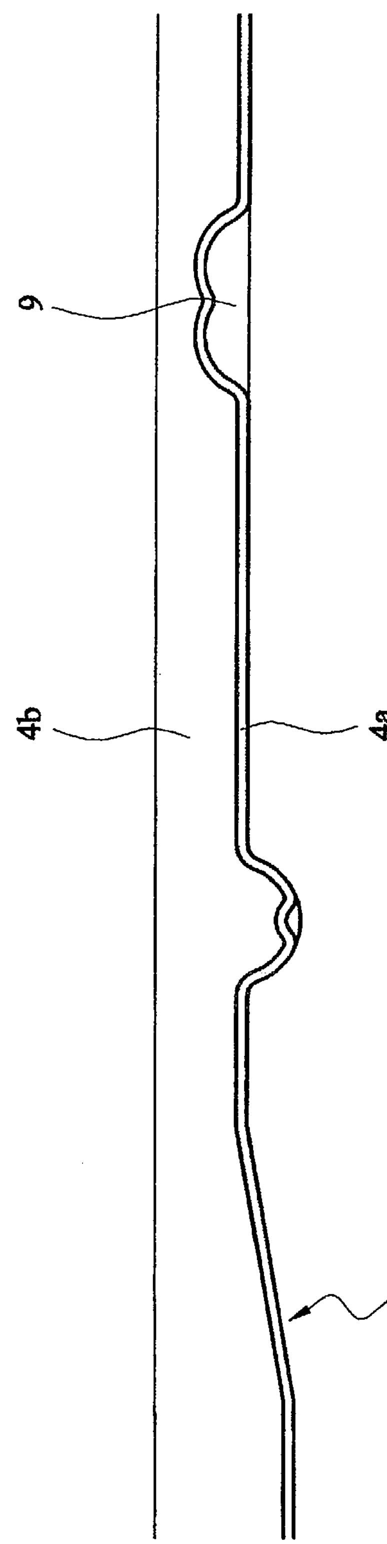

FIG. 7

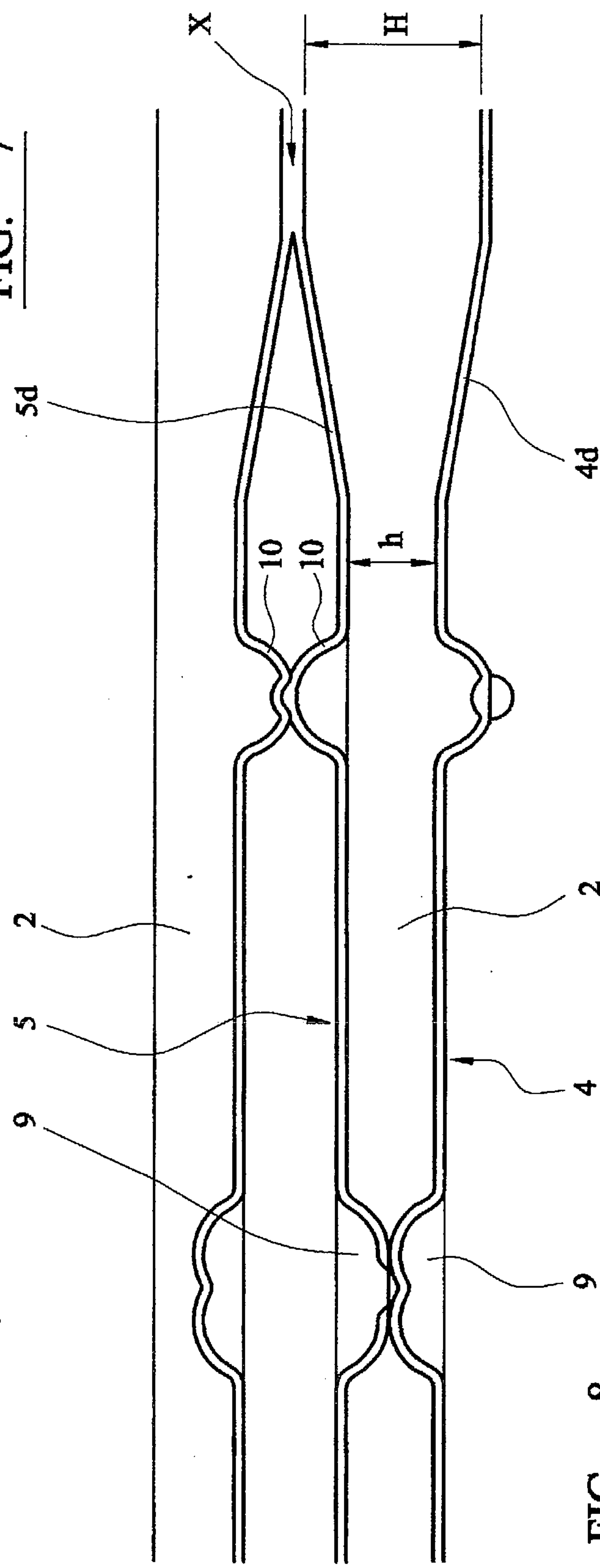

FIG. 8

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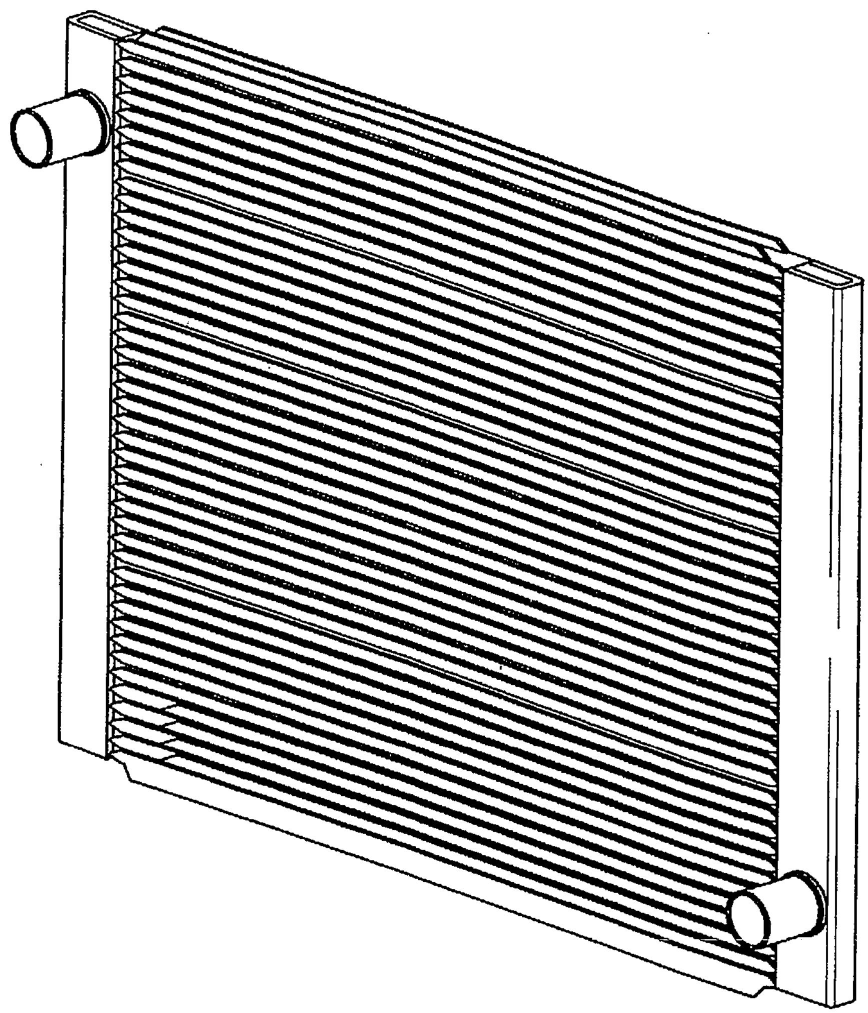

FIG. 9

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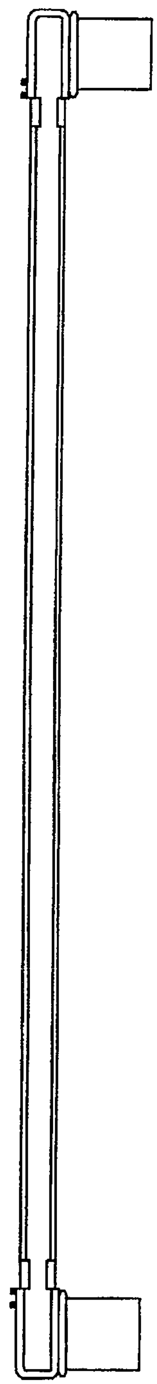

FIG. 10

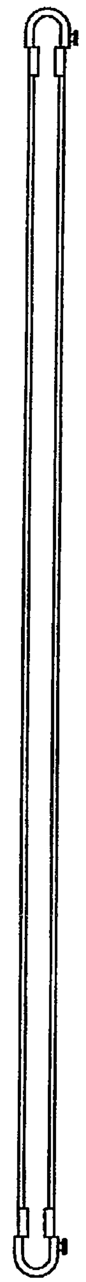

FIG. 13

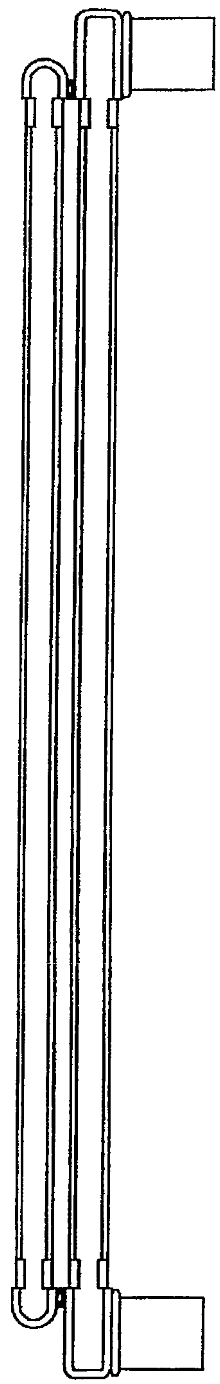

FIG. 16

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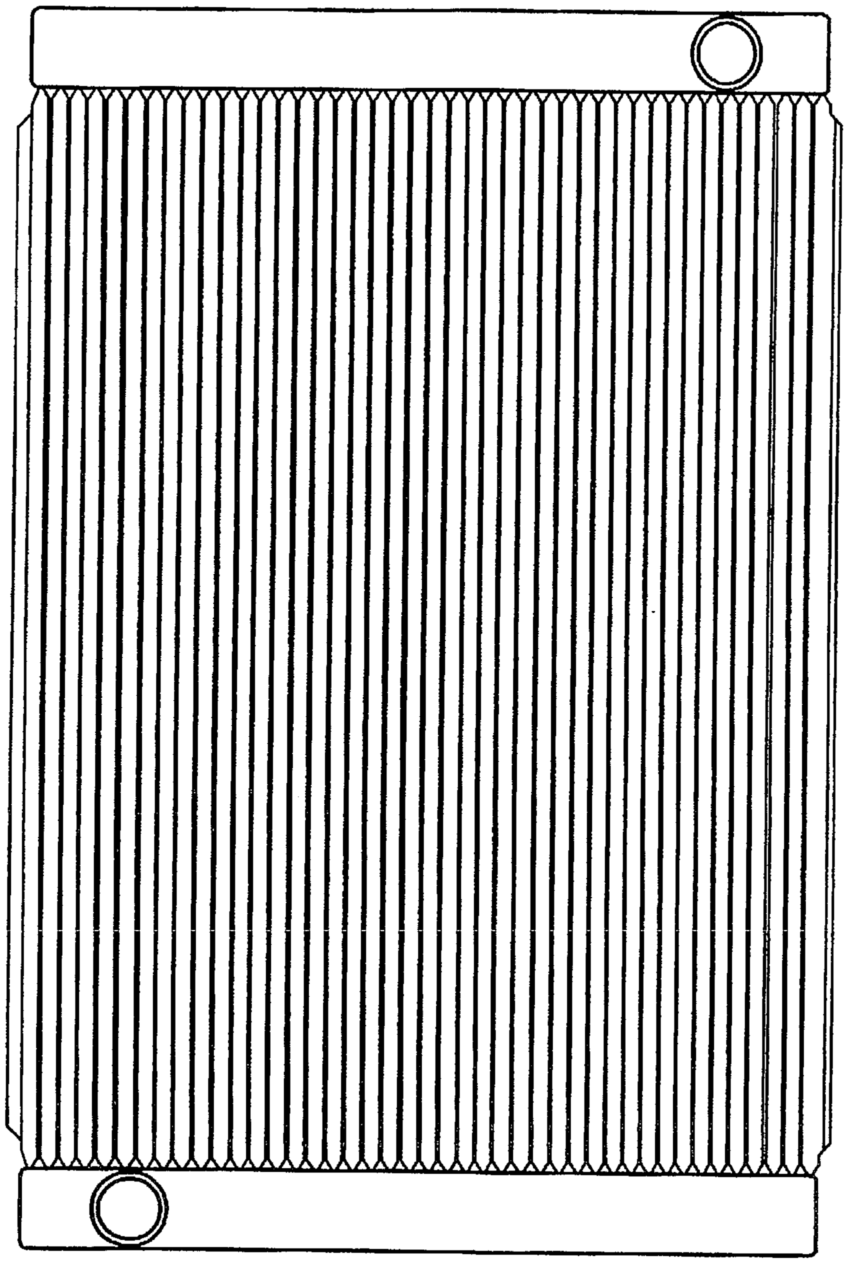

FIG. 11

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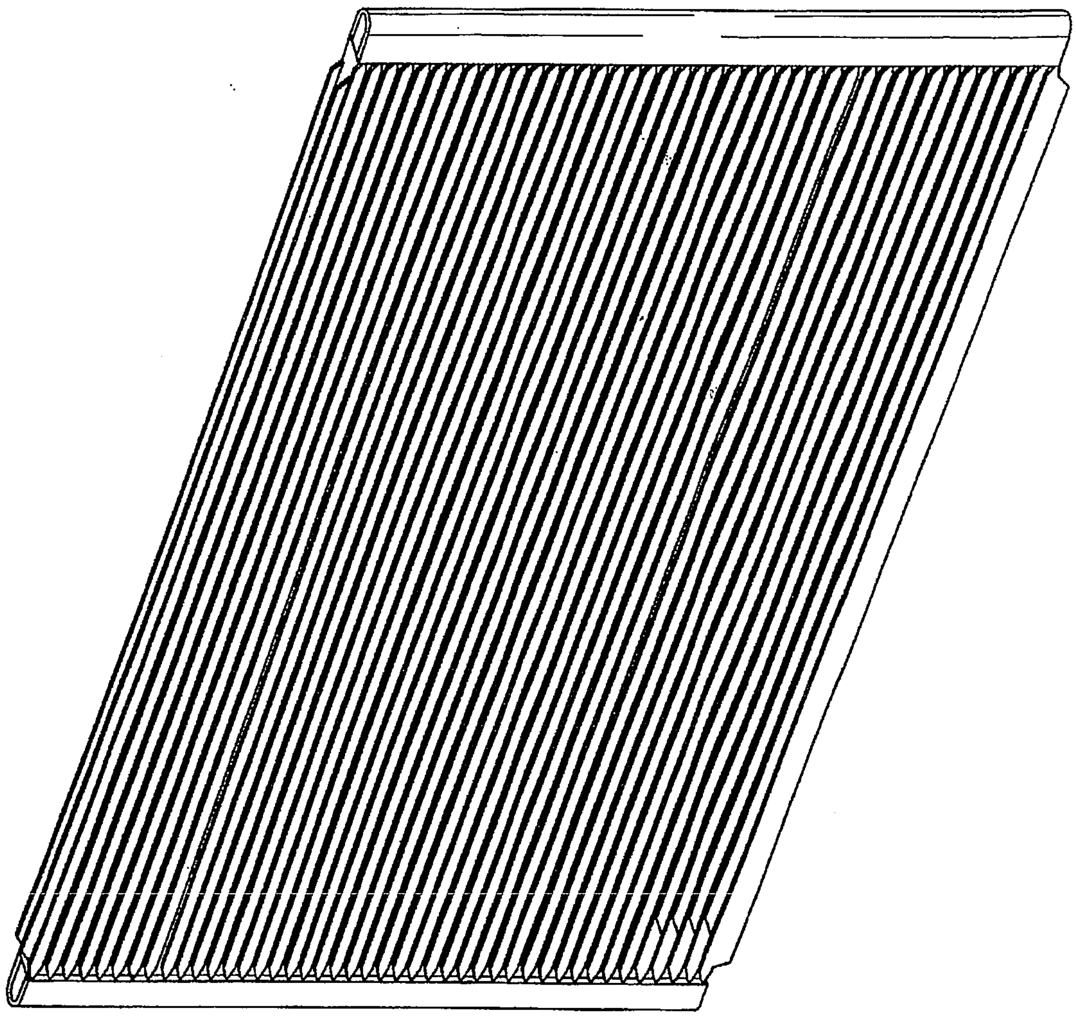

FIG. 12

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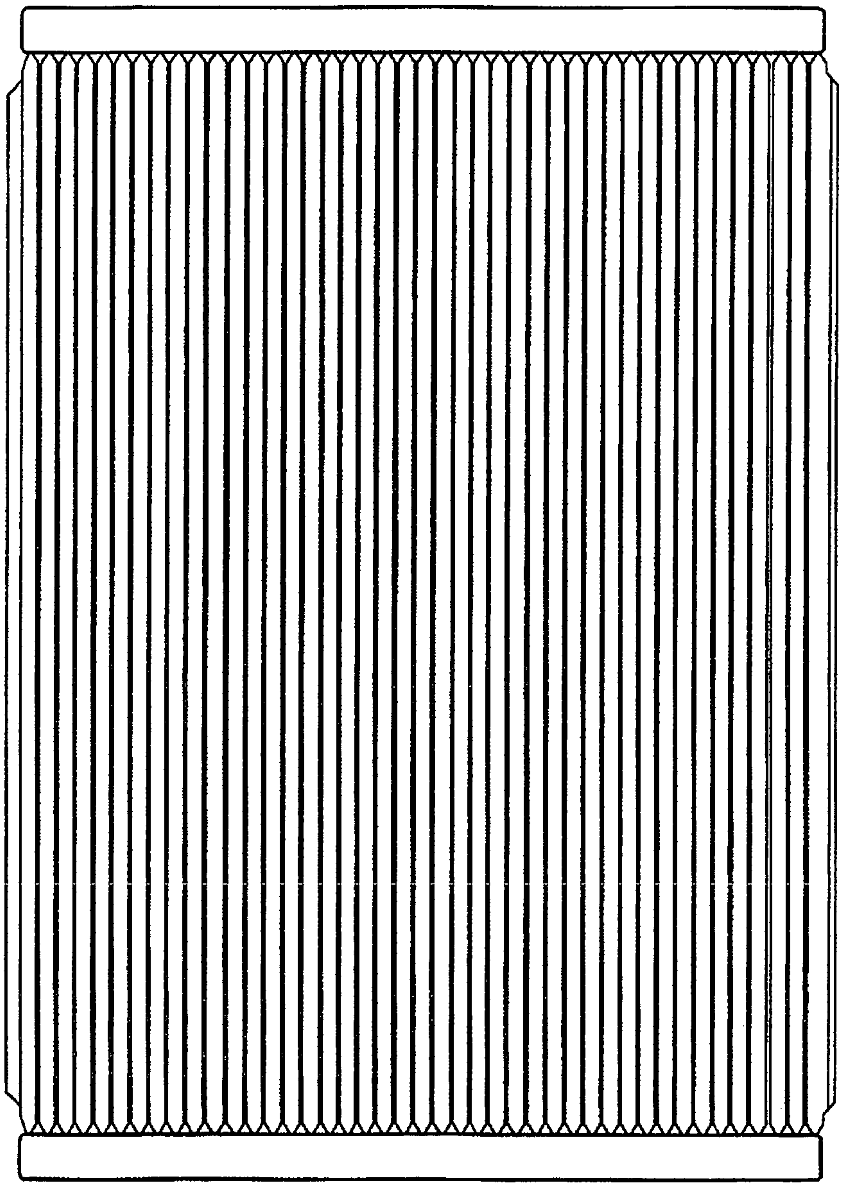

FIG. 14

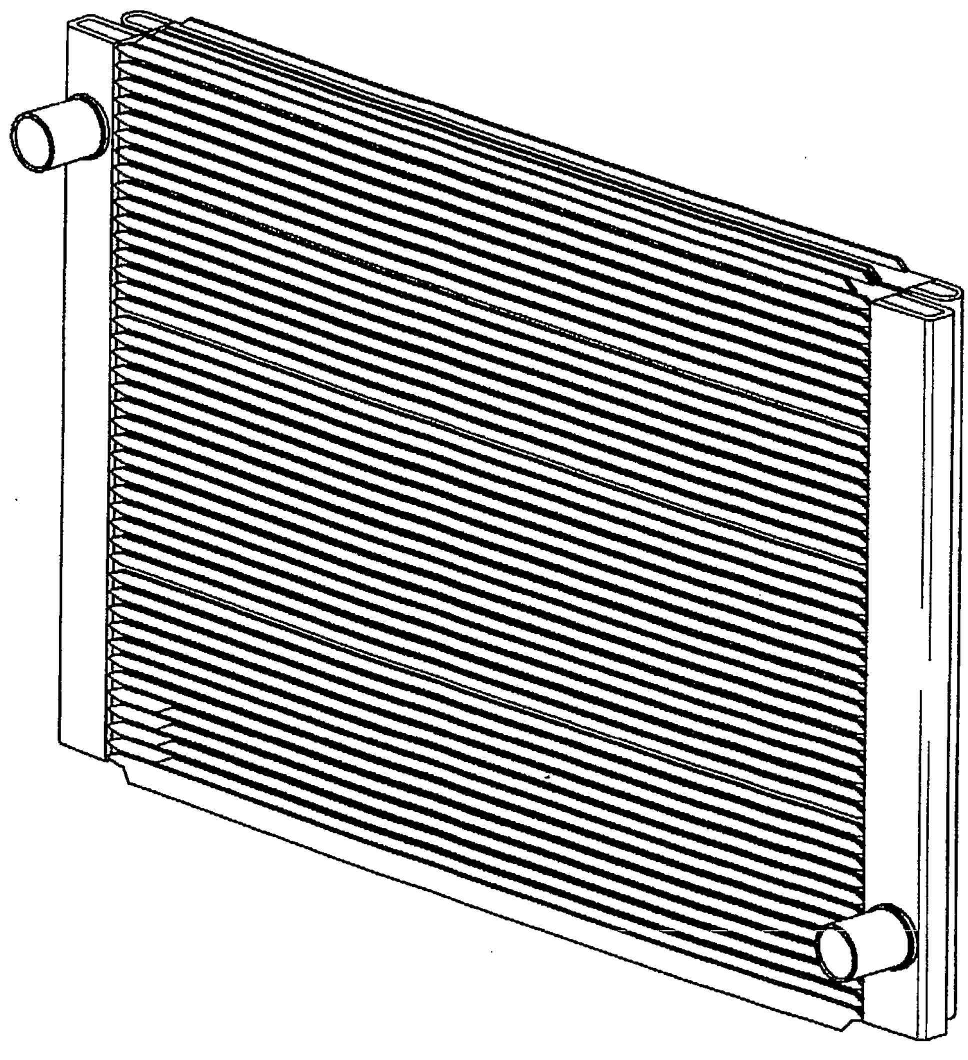

FIG. 15

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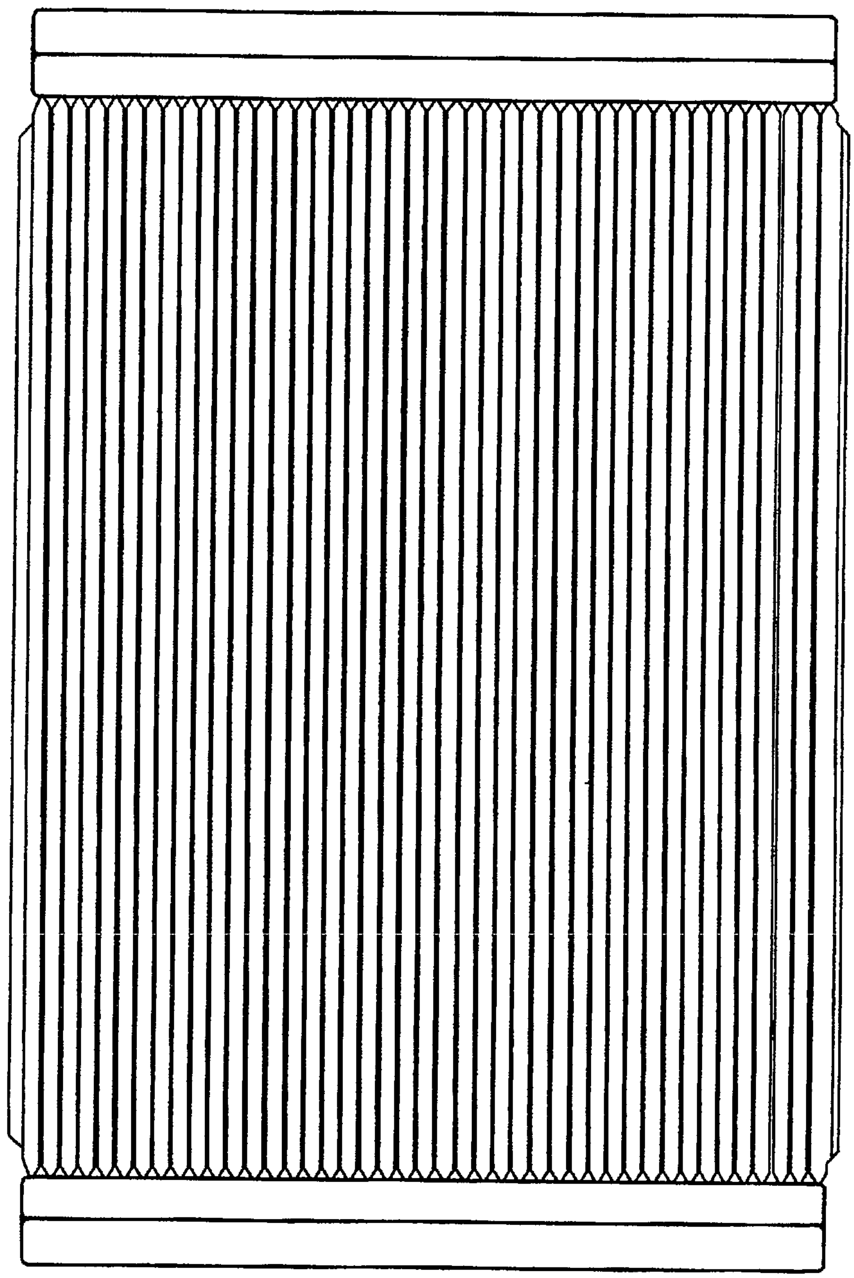

FIG. 17

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Automotive Heat Exchanger

The present invention relates to an automotive heat exchanger, and in particular to an automotive heat exchanger comprising mating plates defining tubes for a fluid medium.

According to a first aspect of the present invention provides an automotive heat exchanger comprising respective flowpath arrays for a first fluid medium and a second fluid medium comprising air; a series of tubes for the first fluid medium comprising joined mating plates, the tubes having opposed open ends and a flow path extending between the open ends, adjacent tubes having spaced external surface portions defining the flowpath array for the air fluid medium.

It is preferred that the flowpath arrays are configured to direct the flow of the first fluid medium and a second fluid medium comprising air in mutually transverse (preferably substantially perpendicular) directions.

For a respective tube, it is preferred that one or both plates include internally projecting formations arranged to form contact zones internally of the tube. For a respective tube, both plates preferably include internally projected formations, the internally projected formations contacting one or other internally of the tube.

The internally projecting formations serve to strengthen the construction and also provide turbulation for the fluid medium flowing internally of the tubes.

It is preferred that the internally projecting formations comprise dimples, preferably arranged in transverse rows, beneficially a plurality of rows being spaced along the length of the tube.

One or both plates defining the respective tube preferably include externally projecting formations arranged to form contact zones with adjacent tubes, the contact zones being externally of the respective tubes defining the flowpath array for the air medium. Beneficially adjacent plates of adjacent spaced tubes comprise correspondingly co-aligned externally projecting formations arranged to contact one another. Preferably the externally projecting formations comprise elongate ridges extending transversely to the longitudinal direction of the tubes, a series of substantially parallel ridges preferably being spaced in the longitudinal direction of the tubes.

The internally and externally projecting formations ensure that the heat exchanger can be built up as a stack of plates prior to fusion bonding; accurate spacing of the plates for the tubes and inter-tube airways is ensured by the internally and externally projecting formations.

Beneficially the plates comprising respective tubes have overlapping marginal portions, and spanning portions extending between the marginal portions. Beneficially the

marginal portions extend substantially perpendicularly to the respective spanning portions.

Preferably the tubes, in the region of the open ends, comprise relatively wider open mouth portions leading to a relatively narrower tube width extending in the region between the open ends of the tube. The width of the tube is in the direction of the stacked array of tubes in the heat exchanger. The relatively wider open mouth portions preferably taper to the narrower tube width dimension in the region extending between the open ends of the tube. Beneficially adjacent tubes contact one another in the region of the relatively wider open mouth portions.

Beneficially the plates comprising the tube are of aluminium material. The plates comprising the tubes preferably have an aluminium core alloy of relatively high strength, and an external cladding material of aluminium brazing alloy. This arrangement is highly beneficial in that it enables the construction to be assembled from the plates built up one adjacent another and subsequently brazed in a single shot brazing operation. A good brazed join and seal is effected at the contact zones between the externally and internally projecting formations and also along the overlapping lengths of the marginal portions comprising the respective plates.

In one embodiment the first medium may also comprise air. This enables the construction to be used for a charge air cooler for air subsequently to be directed to a turbo-charger arrangement.

In an alternative embodiment the arrangement may be used as an automotive radiator in which the first fluid medium will typically comprise liquid engine coolant (water).

In a further alternative embodiment the heat exchanger may comprise an automotive condenser for a vehicle air conditioning system, in which the first fluid medium will comprise a refrigerant.

In general terms the arrangement provides an alternative to conventional constructions of heat exchanger which usually include tube-internal turbulators and external tube airway matrix fins. The internal projecting formations provide turbulation; the external tube formations provide strength and air flow direction. The arrangement enables relatively thin gauge aluminium plate material to be utilised such as gauges less than .3mm. Relatively low spacing between the tubes less than or equal to 2mm may also be achieved. The arrangement can also be utilised for combined, automotive radiators and condensers such as those referred to as unified condenser radiators. These terms are well known in the art. The arrangement of the present invention provides more compact heat exchanger units compared to prior art arrangements whilst still having comparable efficiency.

The length of pass of the first fluid material through the automotive heat exchanger is substantially greater than the length of flow of the air through the heat exchanger in the transverse direction. Typically the length of passage of the first fluid medium is five times more (or more

preferably ten times more) than the length or passage of the second media comprising air through the heat exchanger.

The invention will now be further described in specific embodiments by way of example only with reference to the accompanying drawings in which:

Figure 1 is a schematic perspective view of a first embodiment of a heat exchanger according to the invention comprising a charge air cooler;

Figure 2 is a schematic representation of mating plates defining a tube for use in a heat exchanger in accordance with the invention;

Figure 3 is a partial schematic sectional view of a portion of the arrangement of Figure 2;

Figure 4 is a perspective view of a single plate for mating with a corresponding plate to form a tube for use in accordance with the invention;

Figure 5 is a sectional view through a portion of the plate of Figure 4;

Figure 6 is an expanded view of the view of Figure 4;

Figure 7 is a schematic sectional longitudinal view along a plate of Figures 4 and 6;

Figure 8 is a schematic sectional view through a heat

exchange tube formed in accordance with the invention and an adjacent plate layer;

Figure 9 is a schematic perspective view of a pressed tube radiator assembly in accordance with the invention;

Figure 10 is a schematic plan view of a pressed tube radiator assembly in accordance with the invention;

Figure 11 is a schematic side view of a pressed tube radiator assembly in accordance with the invention;

Figure 12 is a schematic perspective view of a pressed tube condenser assembly in accordance with the invention;

Figure 13 is a schematic plan view of a pressed tube condenser assembly in accordance with the invention;

Figure 14 is a schematic side view of a pressed tube condenser assembly in accordance with the invention;

Figure 15 is a schematic perspective view of a pressed tube combined or unified condenser and radiator assembly in accordance with the invention;

Figure 16 is a schematic plan view of a pressed tube unified or combined condenser and radiator assembly in accordance with the invention; and

Figure 17 is a schematic side view of a pressed tube unified or combined condenser and radiator assembly in accordance with the invention.

Referring to the drawings, Figure 1 shows a charge air cooler (generally designated 1) formed in accordance with the invention by joining mating plates to define tubes 2 extending in a longitudinal direction A. The tubes are spaced as will be explained hereinafter to define inter-tube airways 3. The arrangement is such that a first heat transfer medium travels through tubes 2 in the direction of arrow A. The second air flow medium flows through inter-tube airways 3 in the direction of arrow B (the direction of arrow B is perpendicular to the direction of arrow A). In the example showing in Figure 1, both the first and second fluid medium are arc, for other embodiments the first medium may comprise liquid, vapour or a liquid/vapour mix. In accordance with the invention the second fluid medium will always be gas (air).

Referring to Figure 2, there is shown a heat exchange tube 2. Shown also in Figure 4 and 6, each heat exchange tube 2 comprises a pair of mating plates 4,5 which are substantially identical although inverted relative one another to form a respective tube. Shown in Figure 5 each plate 4,5 comprises a core 6 of high strength aluminium alloy and an external surface cladding 7 of aluminium brazing alloy (for example an Al-Si alloy). An internal corrosion resistant cladding layer 8 may also be provided. In certain circumstances brazing alloy layer 7 and corrosion resistant layer 8 may be reversed.

The plates 4,5 include respective spanning portions 4a,5a and respective marginal portions 4b,5b, 4c,5c extending transversely to the spanning portions 4a,5a. Respective marginal portions 4b,5b, 4c,5c overlap and, subsequent to brazing, form a sealed brazed joint along the marginal lengths of tube 2. Each tube 2 comprises a series of spaced rows of pressed dimples 9 projecting internally into the interior of the tube. The inwardly projecting dimples 9 on adjacent mating plates 4,5 are co-aligned to contact and abut one another internally of the respective tube 2. This is shown most clearly in Figure 8. The contact between the dimples 9 (as well as the presence of the deformed dimples in the relevant plate 4,5) enhances the overall strength and rigidity of the construction. In addition to the dimples 9 projecting inwardly into the interior of the respective tube, each plate 4,5 includes a series of outwardly projecting ridge formations 10 extending transversely to the longitudinal direction of the tube 2. The ridge formations 10 provided on adjacent plates defining adjacent tubes 2 are co-aligned to abut one another and provide rigidity and accurate spacing between the respective tubes 2 (to define the airway depth/spacing). The spacing between ridges 10 in the longitudinal direction of the tubes 2 can be varied to achieve the required Reynolds number for the theoretical fluid flow for the relevant application of the particular heat exchanger. This will vary between different applications (such as for condensers, radiators, charge air coolers) dependent upon the different fluids flowing through the relevant tube 2 airway with respect to the air flowing transversely in the inter-tube airways.

It should be noted that the ridges 10 are provided with respective proud standing super-ridges 10a and recesses 10c such that when adjacent plates 4,5 in adjacent tubes 2 are stacked (and the relevant plates inverted) super-ridges 10a mate with recesses 10c.

Respective plates 4,5 are also provided with relatively wider mouth portions (dimension H) and relatively narrower tube length portions (dimension h) (see Figure 2). This is achieved by respective tapering portions 4d,5d at the margins of the plates 4,5. This enables adjacent tubes to be brazed to one another at an interface X (see Figure 8). A conventional header tank tube plate may therefore not be required.

The arrangement provided has numerous applications and is believed to be applicable for automotive heat exchangers such as charge air coolers (as shown in Figure 1), radiator assemblies (as shown in Figures 9 to 11), condenser assemblies (as shown in Figures 12 to 14) and unified or combined condenser and radiator assemblies (as shown in Figures 15 to 17).

CLAIMS:

1. An automotive heat exchanger comprising respective flowpath arrays for a first fluid medium and a second fluid medium comprising air; a series of tubes for the first fluid medium comprising joined mating plates, the tubes having open ends and a flowpath extending between the open ends, adjacent tubes having spaced external surface portions defining the flowpath array for the air fluid medium.

2. An automotive heat exchanger according to claim 1, wherein the flowpath arrays are configured to direct flow of the first fluid medium and the second fluid medium comprising air in mutually transverse directions.

3. An automotive heat exchange according to claim 1 or 2, wherein for a respective tube, one or both plates include internally projecting formations arranged to form contact zones internally of the tube.

4. A heat exchanger according to claim 3, wherein for a respective tube, both plates include internally projecting formations, the internally projecting formations contacting one another internally of the tube.

5. A heat exchanger according to claim 3 or 4, wherein the internally projecting formations internally of the tube comprised dimples arranged in transverse rows, a

plurality of rows being spaced along the length of the tubes.

6. A heat exchanger according to any preceding claim, wherein one or both of the plates defining a respective tube include tube-externally projecting formations arranged to form contact zones with adjacent tubes, the contact zones being externally of the respective tubes in the flowpath for the air medium.

7. A heat exchanger according to claim 6, wherein adjacent plates of adjacent spaced tubes comprises correspondingly co-aligned tube-externally projecting formations arranged to contact one another.

8. A heat exchanger according to claim 6 or claim 7, wherein the externally projecting formations comprise elongate ridges extending transversely to the longitudinal direction of the tubes.

9. A heat exchanger according to claim 8, wherein a series of substantially parallel ridges are provided, spaced in the longitudinal direction of the tubes.

10. A heat exchanger according to any preceding claim, wherein the plates comprising a respective tube have overlapping marginal portions and spanning portions extending between the marginal portions.

11. A heat exchanger according to claim 10, wherein, for a respective plate, the marginal portions extend substantially perpendicular to the spanning portions.

12. A heat exchanger according to any preceding claim, wherein the tubes in the region of their open ends comprise relatively wide open mouth portions, leading to a narrower tube width extending between the open ends.

13. A heat exchanger according to claim 12, wherein the relatively wide mouth portions taper to the narrower tube width dimension extending between the open tube ends.

14. A heat exchanger according to claim 12 or claim 13, wherein adjacent tubes contact one another in the region of the relatively wide open mouth portions.

15. A heat exchanger according to any preceding claim, wherein the plates comprising the tube are of aluminium material.

16. A heat exchanger according to any preceding claim, wherein the plates comprising the tubes comprise an aluminium core alloy of relatively high strength and a cladding material of aluminium brazing alloy.

17. A heat exchanger according to any preceding claim, wherein the first fluid medium also comprises air.

18. A heat exchanger according to any preceding claim comprising an automotive charge air cooler for air directed to a turbo charger arrangement.

19. A heat exchanger according to any of claims 1 to 17, comprising an automotive radiator.

20. A heat exchanger according to any of claims 1 to 17, comprising an automotive condenser for a vehicle air conditioning system.

21. A method of manufacturing an automotive heat exchanger comprising assembling a stack of preformed plates to form an assembled heat exchanger according to any preceding claim and subsequently bonding the assembly in a fusion bonding process.

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Application No: GB 0201309.2 -14- **Examiner:** Robert Barrell
Claims searched: 1 - 21 **Date of search:** 29 July 2002

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.T): F4S (S2A, S2B, S4F, S5F, S2M, S42A, S4B, S4J & S4E2) & F4H (HG)

Int Cl (Ed.7): F25B (39/04), F28B (1/06), F28D (1/053 & 7/16) & F28F (1/02, 1/06, 1/08, 1/22, 1/26, 1/32, 1/42, 3/02, 3/04, 13/06 &13/08)

Other: ONLINE EPODOC, WPI & JAPIO

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	GB 2347997 A	LONG MANUFACTURING, See: fig 2 - plate pairs 16, fins 38, internal dimples 20; page 5 line 20 - page 6, line 11 - description of above, and; page 10, line 20 - brazing	1 - 4, 6, 8, 9 & 17 - 21
X	US 6073688 A	ZEXEL, See: fig 4 - plate pair 2A & 2B, internal dimples 11; fig 3 - fins 5; and; column 6, line 59 - column 7, lines 3 - 7 - brazed aluminium	1 - 3, 6, 8, 9, & 15 - 21
X	US 6016865 A	ALFA LAVAL See: fig 2 - parallel external ridges 22; fig 4 - plates 27 & 28 and contacting projection 26, and; column 4, lines 46 - 63 - description of above.	1, 6 - 9, 17 & 21
X	US 5369883 A	LONG MANUFACTURING See: fig 5 - plates 1 & 2, joint 14, external projections 5, contacting at 17; fig 6 cross-flow arrows; column 5, lines 32 - 36 - bonding by brazing and; column 14, lines 16 - 20 - aluminium.	1, 2, 6, 7, 10, 11, 15, & 17 - 21

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

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Application No: GB 0201309.2 - 15 - **Examiner:** Robert Barrell
Claims searched: 1 - 21 **Date of search:** 29 July 2002

Category	Identity of document and relevant passage		Relevant to claims
X	US 3757856 A	UNION CARBIDE See: figs 2 & 3 - plates 24 & 26, external projections 36, internal formation 38; column, 2 line 60 - column 3, line 65 - construction of above, and; column, lines 56 - 64 - brazed clad aluminium.	1 - 3, 6, 7, 15, 16, 19 & 21
X	JP 2001116472	KAWASAKI THERMAL ENG. See: fig 3 - plates P, joint 11, internal dimples 20 contacting at 21, external dimples 16 contacting at 17, fluid paths 9A & 9B, and; WPI abstract - description of above.	1, 3, 4, 6, 7 & 17 -21

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.